REMARKS

This request for reconsideration is being filed in response to the Office Action dated May 20, 2008. For the following reasons this application should be allowed and the case passed to issue.

Claims 1, 3, and 5-31 are pending in this application. Claims 1, 3, and 5-30 are rejected. Claims 2 and 4 were previously canceled.

It is noted that claim 31 was not addressed in the May 20, 2008 Office Action. It is respectfully requested that claim 31 be examined and allowed in the next official action.

Claim Rejections Under 35 U.S.C. § 103

Claims 1, 3, and 7 were rejected under 35 U.S.C. 35 § 103(a) as being unpatentable over Oki (CN 1421541) in view of Takemura et al. (U.S. Pat. No. 6,342,109) (Takemura et al. `109).

Claim 5 was rejected under 35 U.S.C. 35 § 103(a) as being unpatentable over Oki in view of Takemura et al. `109 and further in view Takemura et al. (U.S.Pat. No. 6,224,688) (Takemura et al. `688).

Claims 1, 7, 10, 16, 19, 25, and 28 were rejected under 35 U.S.C. 35 § 103(a) as being unpatentable over Oki in view of Takemura et al. `109 and Brothers (U.S. Pat. No. 6,328,009). Claim 6 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Oki in view of Takemura et al. `109 and further in view of Yoshida et al. (U.S. Pat. No. 5,803,993).

Claims 1, 7, 13, 25, and 28 were rejected under 35 U.S.C. 35 § 103(a) as being unpatentable over Oki in view of Takemura et al. `109 and further in view of Faville (U.S. Pat. No. 5,979,383) .

Claims 1, 7, 10, 22, 25, and 28 were rejected under 35 U.S.C. 35 § 103(a) as being unpatentable over Oki in view of Takemura et al. `109 and further in view of Bando (U.S. Pat. No. JP63-185917) .

Claims 8, 9, 11, 12, 17, 18, 20, 21, 26, 27, 29, and 30 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Oki in view of Takemura et al. (`109) and further in view of Brothers and Kim et al. (Journal of Heat Treat.).

Claims 8, 9, 14, 15, 26, 27, 29, and 30 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Oki in view of Takemura et al. `109 and further in view of Faville and Kim et al.

Claims 8, 9, 11, 12, 23, 24, 26, 27, 29, and 30 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Oki in view of Takemura et al. `109 and further in view of Bando and Kim et al.

These rejections are traversed, and reconsideration and withdrawal thereof respectfully requested. Certified English translations of the Japanese priority documents, JP 2002-303036 and JP 2003-053505 are attached to this response. The filing dates of JP 2002-30303 (October l7, 2002) and JP 2003-053505 (February 28, 2003) precede the publication date of Oki. Therefore, Oki is not prior art and all the above rejections should be withdrawn.

Claims 1, 3, 5, 7, 10, 16, 19, 25, and 28 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Brothers in view of Mitamura (U.S. Pat. No. 5,085,733), Takemura et al. `688, and Takemura et al. `109 and further in view of Ueda et al. (JP 10-204612).

Claims 1, 3, 5, 7, 13, 25, and 28 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Faville et al. (U.S. Pat. No. 5,979,383) in view of Mitamura, Takemura et al. `688, and Takemura et al. `109 and further in view of Ueda et al.

Claims 1, 3, 5, 7, 10, 22, 25, and 28 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Bando (JP63-185917) in view of Mitamura, Takemura et al. `688, and Takemura et al. `109 and further in view of Ueda et al.

These rejections are traversed, and reconsideration and withdrawal thereof respectfully requested. The following is a comparison between the present invention, as claimed, and the cited prior art.

An aspect of the invention, per claim 1, is a full-type rolling bearing formed of an outer ring, an inner ring and rollers that are made of steel, wherein at least one of the outer ring, inner ring and rollers contains a non-diffusible hydrogen content of at most 0.5 ppm, carbon in an amount of 0.95% to 1.10%, silicon in an amount of 0.15% to 0.35%, manganese in an amount of at most 0.5%, phosphorous in an amount of at most 0.025%, sulfur in an amount of at most 0.025%, chromium in an amount of 1.30% to 1.60%, and molybdenum in an amount of less than 0.08%, with the remainder formed of Fe and unavoidable impurities, has a carbonitrided layer in its surface layer, and the austenite crystal grain size number of the surface layer is greater than 10. After at least one of the outer ring, inner ring and rollers is carbonitrided at a carbonitriding temperature equal to or higher than the A1 transformation temperature, the at least one of the outer ring, inner ring and rollers is cooled to a temperature lower than the A1 transformation temperature and then heated to a quenching temperature of 790°C - 815°C and thereby quenched.

Another aspect of the invention, per claim 7, is a roller cam follower of an engine comprising an outer ring being in rolling contact with a cam shaft of the engine. A roller shaft is located inside the outer ring and fixed to a cam follower body and bearing elements are placed between the outer ring and the roller shaft. At least one of the outer ring, roller shaft and bearing elements contains a non-diffusible hydrogen content of at most 0.5 ppm, carbon in an amount of 0.95% to 1.10%, silicon in an amount of 0.15% to 0.35%, manganese in an amount of at most 0.5%, phosphorous in an amount of at most 0.025%, sulfur in an amount of at most 0.025%,

chromium in an amount of 1.30% to 1.60%, and molybdenum in an amount of less than 0.08%, with the remainder formed of Fe and unavoidable impurities, has a carbonitrided layer and austenite crystal grains in at least a surface layer are made fine to have a grain size number greater than 10. After at least one of the outer ring, roller shaft, and bearing elements is carbonitrided at a carbonitriding temperature equal to or higher than the A1 transformation temperature, the at least one of the outer ring, roller shaft and bearing elements is cooled to a temperature lower than the A1 transformation temperature and then heated to a quenching temperature of 790°C - 815°C and thereby quenched.

The Examiner averred that Brothers, Faville et al., and Bando disclose full type rolling bearings formed of an outer ring, an inner ring, and rollers. The Examiner acknowledged that Brothers, Faville et al., and Bando do not disclose the compositions of JIS-SUJ2 steel, that at least one of the outer ring, roller shaft, and bearing elements are made of steel, has a carbonitrided surface layer, an austenite crystal grain size number greater than 10, and a non-diffusible hydrogen content of at most 0.5 ppm. The Examiner relied on the teaching of Mitamura of JIS-SUJ2 to conclude it would have been obvious to use JIS-SUJ2 steel to secure a long rolling fatigue life. The Examiner relied on the teaching of Takemura et al. `688 of rolling bearings that have a carbonitrided layer and a crystal grain size greater than 11 to assert that it would have been obvious to use the steel of Takemura et al. `688 in the rolling bearings of Brothers, Faville et al., and Bando to achieve long life and high reliability. The Examiner relied on the teaching of Takemura et al. `109 of keeping the diffusible hydrogen content to not more than 0.1 ppm in order to enhance brittleness and the alleged teaching of Ueda et al. to assert that a non-diffusible hydrogen content of less than 0.5 ppm to prevent soot would have been obvious. The Examiner further asserted that Takemura et al. (U.S. Pat. No. 6,440,232) (Takemura et al.

`232) disclose the inherent manufacturing steps of carbonitriding (Fig. 3A). The Examiner further referred to Maeda et al. as showing a quenching temperature of 800 °C to 840 °C to adjust the size of the structure.

The Examiner-asserted combination of references do not suggest the claimed full-type rolling bearings and roller cam followers because it would not have been obvious to combine the Mitamura teaching of JIS-SUJ2 with the other cited references. There is no motivation to combine the Mitamura teaching of JIS-SUJ2 with the other cited references. Contrary to the Examiner's assertions, Mitamura teaches away from using JIS-SUJ2 (see column 2, line 41 to column 3, line 36; Table 2 and column 12, lines 42-60). Mitamura teach that JIS-SUJ2 provides inferior hardness and L10 life. Mitamura teaches the use of JIS-SUJ2 in Table 1 (material C). In Table 2 Mitamura discloses that material C is used to produce test pieces Nos. 5 and 13. Unlike the other test pieces, Nos. 5 and 13 were heat treated without carburization and carbonitriding (column 10, lines 27-30 and lower portion of Table 2). Similarly, materials P and Q (Table 3) are JIS-SUJ2, and these materials were also heat-treated without carburization and carbonitriding (Table 4). Thus, Mitamura clearly teach away from carburizing or carbonitriding JIS-SUJ2 steel. JIS-SUJ2 already has a high carbon concentration, therefore, one of skill in this art would not have been motivated to carburize or carbonitride JIS-SUJ2.

The steel of Mitamura corresponds to sample No. 11 (Table 1, of the present specification), which is JIS-SUJ2 bearing steel, normally heat-treated without carburization or carbonitriding, while the steel of the present invention corresponds to samples No. 1-10.

Further contrary to the Examiner's assertions, there is ample support in the instant specification for unexpected results in a number of critical properties of the claimed carbonitrided bearing parts. As disclosed in the present specification, the claimed full-type

rolling bearing and roller cam followers have unexpectedly improved relative rolling life over sample No. 11 (the steel of Mitamura), as illustrated in Table 3; unexpectedly improved peeling strength, relative peeling strength, relative crack strength, and relative crack fatigue strength over sample No. 11, as shown in Table 4; and unexpectedly reduced hydrogen content and stress fracture in Table 9. Furthermore, Takemura et al. `232 do not disclose the <u>inherent</u> manufacturing steps of carbonitriding. Takemura et al. `232 disclose **three different carbonitriding** procedures in Fig. 3, thus, it is clear that <u>no</u> single carbonitriding process is <u>inherent,</u> as averred by the Examiner.

It would have been further unobvious to combine Ueda et al. with the other cited references because the composition of the Ueda et al. steel is very different from JIS-SUJ2, so that one would not expect the same properties disclosed by Ueda et al. to be present in the JIS-SUJ2 steel taught by Mitamura et al. Ueda et al. teach (Table 1) steel having a carbon content of at most 0.41%, which is much less than the claimed 0.95% to 1.10% carbon. Furthermore, Ueda et al. disclose Mn, Ni, and Mo concentrations which are higher than the claimed range. Therefore, combining the steel composition of Ueda et al. with Brothers, Faville et al., Bando, Mitamura, Takemura et al. `688, and Takemura et al. `109 would not result in the claimed full-type rolling bearing and roller cam follower. Furthermore, the steel of Ueda et al. is subjected to carburizing treatment or carbonitriding treatment and thereafter heated under vacuum, unlike the steel in the present invention, to reduce the hydrogen content. Thus, the steel of Ueda et al. is very different from the steel in the claimed full-type rolling bearing and roller cam follower. The steel used in the present invention has a non-diffusible hydrogen content of at most 0.5 ppm by the claimed heat treatment, without heating it under vacuum, as in Ueda et al.

The claimed full-type rolling bearings and roller cam followers are further unobvious because SUJ2 steel has a high carbon concentration (0.95% -1.10%). Therefore, it had been difficult to carbonitride SUJ2 steel in the manner disclosed, for example, in Takemura et al. `232 for the following reasons:

i) In order to carbonitride SUJ2 steel, it is necessary to increase the carbon concentration in the carbonitriding atmosphere to an extremely high concentration (for example, Cp = approximately 1.2-1.4), which results in damage to the carbonitriding furnace or causes a phenomenon of deteriorating the productivity of the steel (such as sooting).

ii) In order to prevent the amount of retained austenite from abnormally increasing and ensure a high hardness of the steel, it is necessary to carbonitride the steel at a temperature of approximately 850°C. At this temperature, however, the diffusion coefficient of carbon is low. Thus, even if SUJ2 is carbonitrided, the carbonitrided layer cannot be formed to a suitable depth in the steel.

iii) If carbonitriding is carried out at a temperature higher than 850°C for the purpose of increasing the carbonitriding speed, quenching cracks are likely to occur during quenching.

In addition, if the conventional carbonitriding process as disclosed, for example in Takemura et al. `232, is performed on SUJ2 steel, the crack strength decreases because the carbonitriding process takes a long time or because the amount of retained austenite in the surface layer is large. Therefore, a steel having the properties of the present invention (e.g. - crystal grain size number larger than 10, hydrogen content at most 0.5 ppm, and fracture strength at least 2650 MPa) cannot be obtained. In the present invention, SUJ2 steel is quenched at a low temperature of

790°C to 815°C so the crystal grains can be made finer and hydrogen entering the steel in the carbonitriding process can be discharged to the outside and the amount of retained austenite can be kept small. As a result, the strength of the steel can be enhanced without shortening the rolling life.

Claim 6 was rejected under 35 U.S.C. 35 § 103(a) as obvious over Brothers in view of Takemura et al. `688 and further in view of Yoshida et al. The Examiner acknowledged that Brothers does not disclose a compression residual stress of at least 500 MPa. The Examiner relied on the teaching of Yoshida et al. of compression residual strength of 850 MPa to assert that it would have been obvious to modify the system of Brothers by providing a residual stress of at least 850 MPa in order to raise the fatigue strength of the device.

The combination of Yoshida et al. with Brothers and Takemura et al. `688 does not suggest the claimed full-type rolling bearing because Yoshida et al. do not cure the deficiencies of Brothers and Takemura et al. `688 in that Yoshida et al. do not suggest that at least one of the outer ring, inner ring and rollers contains a non-diffusible hydrogen content of at most 0.5 ppm, carbon in an amount of 0.95% to 1.10%, silicon in an amount of 0.15% to 0.35%, manganese in an amount of at most 0.5%, phosphorous in an amount of at most 0.025%, sulfur in an amount of at most 0.025%, chromium in an amount of 1.30% to 1.60%, and molybdenum in an amount of less than 0.08%, with the remainder formed of Fe and unavoidable impurities, as required by claim 1.

Claims 8, 11, 17, 20, 26, and 29 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Brothers in view of Mitamura, Hirakawa et al. (U.S. Pat. No. 6,012,851), Kim et al. *(Journal of Heat Treat.)* and Takemura et al. `109, and further in view of Ueda et al.

Claims 8, 14, 26, and 29 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Faville et al. in view of Mitamura, Hirakawa et al., Kim et al., and Takemura et al. `109, and further in view of Ueda et al.

Claims 8, 11, 23, 26, and 29 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Bando in view of Mitamura, Hirakawa et al., Kim et al., and Takemura et al. `109, and further in view of Ueda et al.

These rejections are traversed, and reconsideration and withdrawal thereof respectfully requested. The following is a comparison between the present invention, as claimed, and the cited prior art.

An aspect of the invention, per claim 8, is a roller cam follower of an engine comprising an outer ring being in rolling contact with a cam shaft of the engine. A roller shaft is located inside the outer ring and fixed to a cam follower body and bearing elements are placed between the outer ring and the roller shaft. At least one of the outer ring, roller shaft and bearing elements contains a non-diffusible hydrogen content of at most 0.5 ppm, carbon in an amount of 0.95% to 1.10%, silicon in an amount of 0.15% to 0.35%, manganese in an amount of at most 0.5%, phosphorous in an amount of at most 0.025%, sulfur in an amount of at most 0.025%, chromium in an amount of 1.30% to 1.60%, and molybdenum in an amount of less than 0.08%, with the remainder formed of Fe and unavoidable impurities, has a carbonitrided layer and has a fracture stress of at least 2650 MPa. After at least one of the outer ring, roller shaft, and bearing elements is carbonitrided at a carbonitriding temperature equal to or higher than the A1 transformation temperature, the at least one of the outer ring, roller shaft and bearing elements is cooled to a temperature lower than the A1 transformation temperature and then heated to a quenching temperature of 790° - 815°C and thereby quenched.

The Examiner acknowledged that Brothers, Faville et al., and Bando do not disclose the compositions of JIS-SUJ2 steel, that at least one of the outer ring, roller shaft, and bearing elements are made of steel, has a carbonitrided surface layer, fracture stress of at least 2650 Mpa, and the non-diffusible hydrogen content. The Examiner relied on the teaching of Mitamura of JIS-SUJ2 to conclude it would have been obvious to use JIS-SUJ2 steel to secure a long rolling fatigue life. The Examiner relied on the teaching of Hirakawa et al. of rolling bearings that have a carbonitrided layer and the teaching of Kim et al. that carbonitrided steel can have a fracture stress of 3220 MPa to assert that it would have been obvious to provide a carbonitrided layer to improve physical properties and thereby enhance longevity of the device. The Examiner relied on the teaching of Takemura et al. `109 of keeping the diffusible hydrogen content to not more than 0.1 ppm in order to enhance brittleness and the alleged teaching of Ueda et al. to assert that a non-diffusible hydrogen content of less than 0.5 ppm to prevent soot to assert that the hydrogen content of at most 0.5 ppm would have been obvious. The Examiner further asserted that Takemura et al. (U.S. Pat. No. 6,440,232) (Takemura et al. `232) disclose the inherent manufacturing steps of carbonitriding (Fig. 3A). The Examiner further referred to Maeda et al. as showing a quenching temperature of 800 °C to 840 °C to adjust the size of the structure.

Brothers, Faville et al., Bando, Mitamura, Kim et al., Hirakawa et al., Takemura et al. `109, Takemura et al. `232, Ueda et al., and Maeda et al., whether taken alone, or in combination, do not suggest the claimed roller cam follower because the cited references do not suggest at least one of the outer ring, roller shaft and bearing elements has a carbonitrided layer and contains a non-diffusible hydrogen content of at most 0.5 ppm, carbon in an amount of 0.95% to 1.10%, silicon in an amount of 0.15% to 0.35%, manganese in an amount of at most 0.5%, phosphorous in an amount of at most 0.025%, sulfur in an amount of at most 0.025%, chromium

in an amount of 1.30% to 1.60%, and molybdenum in an amount of less than 0.08%, with the remainder formed of Fe and unavoidable impurities, as required by claim 8.

As explained above, there is no motivation to combine the Mitamura teaching of JIS-SUJ2 with the other cited references. Contrary to the Examiner's assertions, Mitamura teaches away from using JIS-SUJ2 (see column 2, line 41 to column 3, line 36; Table 2 and column 12, lines 42-60). Mitamura teach that JIS-SUJ2 provides inferior hardness and L10 life. Mitamura teaches the use of JIS-SUJ2 in Table 1 (material C). In Table 2 Mitamura discloses that material C is used to produce test pieces Nos. 5 and 13. Unlike the other test pieces, Nos. 5 and 13 were heat treated without carburization and carbonitriding (column 10, lines 27-30 and lower portion of Table 2). Similarly, materials P and Q (Table 3) are JIS-SUJ2, and these materials were also heat-treated without carburization and carbonitriding (Table 4). Thus, Mitamura clearly teach away from carburizing or carbonitriding JIS-SUJ2 steel. JIS-SUJ2 already has a high carbon concentration, therefore, one of skill in this art would not have been motivated to carburize or carbonitride JIS-SUJ2.

The steel of Mitamura corresponds to sample No. 11 (Table 1, of the present specification), which is JIS-SUJ2 bearing steel, normally heat-treated without carburization or carbonitriding, while the steel of the present invention corresponds to samples No. 1-10.

Further contrary to the Examiner's assertions, there is ample support in the instant specification for unexpected results in a number of critical properties of the claimed carbonitrided bearing parts. As disclosed in the present specification, the claimed full-type rolling bearing and roller cam followers have unexpectedly improved relative rolling life over sample No. 11 (the steel of Mitamura), as illustrated in Table 3; unexpectedly improved peeling strength, relative peeling strength, relative crack strength, and relative crack fatigue strength, as

shown in Table 4 over sample No. 11; and unexpectedly reduced hydrogen content and stress fracture in Table 9. Furthermore, Takemura et al. `232 do not disclose the inherent manufacturing steps of carbonitriding. Takemura et al. `232 disclose three different carbonitriding procedures in Fig. 3, thus, it is clear that no single carbonitriding process is inherent, as averred by the Examiner.

It would have been further unobvious to combine Ueda et al. with the other cited references because the composition of the Ueda et al. steel is very different from JIS-SUJ2, so that one would not expect the same properties disclosed by Ueda et al. to be present in the JIS-SUJ2 steel taught by Mitamura et al. Ueda et al. teach (Table 1) steel having a carbon content of at most 0.41%, which is much less than the claimed 0.95% to 1.10% carbon. Furthermore, Ueda et al. disclose Mn, Ni, and Mo concentrations which are higher than the claimed range. Therefore, combining the steel composition of Ueda et al. with Brothers, Faville et al., Bando, Mitamura, Hirakawa et al., Kim et al., and Takemura et al. `109 would not result in the claimed full-type rolling bearing and roller cam follower.

Furthermore, the steel of Ueda et al. is subjected to carburizing treatment or carbonitriding treatment and thereafter heated under vacuum, unlike the steel in the present invention, to reduce the hydrogen content. Thus, the steel of Ueda et al. is very different from the steel in the claimed full-type rolling bearing and roller cam follower. The steel used in the present invention has a non-diffusible hydrogen content of at most 0.5 ppm by the claimed heat treatment, without heating it under vacuum, as in Ueda et al.

Also, there is no motivation to substitute the steel of Takemura et al. `109 with its costly high chromium content for the steel of Hirakawa et al. The steel types taught by Hirakawa et al. are different from those disclosed by Takemura et al. `109. For example, Takemura et al. `109

disclose a steel requiring 2.0 to 9.0 wt % Cr. Thus, there is no suggestion that the steel types taught by Hirakawa et al. would have the claimed hydrogen content.

The claimed full-type rolling bearings and roller cam followers are further unobvious because SUJ2 steel has a high carbon concentration (0.95% -1.10%). Therefore, it had been difficult to carbonitride SUJ2 steel in the manner disclosed, for example, in Takemura et al. `232 for the following reasons:

i) In order to carbonitride SUJ2 steel, it is necessary to increase the carbon concentration in the carbonitriding atmosphere to an extremely high concentration (for example, Cp = approximately 1.2-1.4), which results in damage to the carbonitriding furnace or causes a phenomenon of deteriorating the productivity of the steel (such as sooting).

ii) In order to prevent the amount of retained austenite from abnormally increasing and ensure a high hardness of the steel, it is necessary to carbonitride the steel at a temperature of approximately 850°C. At this temperature, however, the diffusion coefficient of carbon is low. Thus, even if SUJ2 is carbonitrided, the carbonitrided layer cannot be formed to a suitable depth in the steel.

iii) If carbonitriding is carried out at a temperature higher than 850°C for the purpose of increasing the carbonitriding speed, quenching cracks are likely to occur during quenching.

In addition, if the conventional carbonitriding process as disclosed, for example in Takemura et al. `232, is performed on SUJ2 steel, the crack strength decreases because the carbonitriding process takes a long time or because the amount of retained austenite in the surface layer is large. Therefore, a steel having the properties of the present invention (e.g. - crystal grain

size number larger than 10, hydrogen content at most 0.5 ppm, and fracture strength at least 2650 MPa) cannot be obtained. In the present invention, SUJ2 steel is quenched at a low temperature of 790°C to 815°C so the crystal grains can be made finer and hydrogen entering the steel in the carbonitriding process can be discharged to the outside and the amount of retained austenite can be kept small. As a result, the strength of the steel can be enhanced without shortening the rolling life.

Claims 9, 12, 18, 21, 27, and 30 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Brothers in view of Hirakawa et al. and Takemura et al. `109, and further in view of Ueda et al.

Claims 9, 15, 27, and 30 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Faville et al. in view of Hirakawa et al. and Takemura et al. `109, and further in view of Ueda et al.

Claims 9, 12, 24, 27, and 30 were rejected under 35 U.S.C. 35 § 103(a) as obvious over Bando in view of Hirakawa et al., and Takemura et al. `109, and further in view of Ueda et al.

These rejections are traversed, and reconsideration and withdrawal thereof respectfully requested. The following is a comparison between the present invention, as claimed, and the cited prior art.

An aspect of the invention, per claim 9, is a roller cam follower of an engine comprising an outer ring being in rolling contact with a cam shaft of the engine. A roller shaft is located inside the outer ring and fixed to a cam follower body and bearing elements are placed between the outer ring and the roller shaft. Wherein at least one of the outer ring, roller shaft and bearing elements has a carbonitrided layer and contains a non-diffusible hydrogen content of at most 0.5 ppm, carbon in an amount of 0.95% to 1.10%, silicon in an amount of 0.15% to 0.35%, manganese in an amount of at most 0.5%, phosphorous in an amount of at most 0.025%, sulfur

in an amount of at most 0.025%, chromium in an amount of 1.30% to 1.60%, and molybdenum in an amount of less than 0.08%, with the remainder formed of Fe and unavoidable impurities. After at least one of the outer ring, roller shaft, and bearing elements is carbonitrided at a carbonitriding temperature equal to or higher than the A1 transformation temperature, the at least one of the outer ring, roller shaft and bearing elements is cooled to a temperature lower than the A1 transformation temperature and then heated to a quenching temperature of 790° - 815°C and thereby quenched.

The Examiner acknowledged that Brothers, Faville et al., and Bando do not disclose that at least one of the outer ring, roller shaft, and bearing elements has a carbonitrided layer and hydrogen content of at most 0.5 ppm. The Examiner relied on the teaching of Takemura et al. `109 of keeping hydrogen content to not more than 0.1 ppm in order to enhance brittleness and the alleged teaching of Ueda et al. to assert that a non-diffusible hydrogen content of less than 0.5 ppm to prevent soot to assert that the hydrogen content of at most 0.5 ppm would have been obvious.

Brothers, Faville et al., Bando, Mitamura, Hirakawa et al., Takemura et al. `109, Takemura et al. `232, Ueda et al., and Maeda et al., whether taken alone, or in combination, do not suggest the claimed roller cam follower because the cited references do not suggest at least one of the outer ring, roller shaft and bearing elements has a carbonitrided layer and contains a non-diffusible hydrogen content of at most 0.5 ppm, carbon in an amount of 0.95% to 1.10%, silicon in an amount of 0.15% to 0.35%, manganese in an amount of at most 0.5%, phosphorous in an amount of at most 0.025%, sulfur in an amount of at most 0.025%, chromium in an amount of 1.30% to 1.60%, and molybdenum in an amount of less than 0.08%, with the remainder formed of Fe and unavoidable impurities, as required by claim 9.

As explained above, there is no motivation to combine the Mitamura teaching of JIS-SUJ2 with the other cited references. Contrary to the Examiner's assertions, Mitamura teaches away from using JIS-SUJ2 (see column 2, line 41 to column 3, line 36; Table 2 and column 12, lines 42-60). Mitamura teach that JIS-SUJ2 provides inferior hardness and L10 life. Mitamura teaches the use of JIS-SUJ2 in Table 1 (material C). In Table 2 Mitamura discloses that material C is used to produce test pieces Nos. 5 and 13. Unlike the other test pieces, Nos. 5 and 13 were heat treated without carburization and carbonitriding (column 10, lines 27-30 and lower portion of Table 2). Similarly, materials P and Q (Table 3) are JIS-SUJ2, and these materials were also heat-treated without carburization and carbonitriding (Table 4). Thus, Mitamura clearly teach away from carburizing or carbonitriding JIS-SUJ2 steel. JIS-SUJ2 already has a high carbon concentration, therefore, one of skill in this art would not have been motivated to carburize or carbonitride JIS-SUJ2.

The steel of Mitamura corresponds to sample No. 11 (Table 1, of the present specification), which is JIS-SUJ2 bearing steel, normally heat-treated without carburization or carbonitriding, while the steel of the present invention corresponds to samples No. 1-10.

Further contrary to the Examiner's assertions, there is ample support in the instant specification for unexpected results in a number of critical properties of the claimed carbonitrided bearing parts. As disclosed in the present specification, the claimed full-type rolling bearing and roller cam followers have unexpectedly improved relative rolling life over sample No. 11 (the steel of Mitamura), as illustrated in Table 3; unexpectedly improved peeling strength, relative peeling strength, relative crack strength, and relative crack fatigue strength, as shown in Table 4 over sample No. 11; and unexpectedly reduced hydrogen content and stress fracture in Table 9. Furthermore, Takemura et al. `232 do not disclose the inherent

manufacturing steps of carbonitriding. Takemura et al. `232 disclose three different carbonitriding procedures in Fig. 3, thus, it is clear that no single carbonitriding process is inherent, as averred by the Examiner.

It would have been further unobvious to combine Ueda et al. with the other cited references because the composition of the Ueda et al. steel is very different from JIS-SUJ2, so that one would not expect the same properties disclosed by Ueda et al. to be present in the JIS-SUJ2 steel taught by Mitamura et al. Ueda et al. teach (Table 1) steel having a carbon content of at most 0.41%, which is much less than the claimed 0.95% to 1.10% carbon. Furthermore, Ueda et al. disclose Mn, Ni, and Mo concentrations which are higher than the claimed range. Therefore, combining the steel composition of Ueda et al. with Brothers, Faville et al., Bando, Mitamura, Hirakawa et al., and Takemura et al. `109 would not result in the claimed full-type rolling bearing and roller cam follower.

Furthermore, the steel of Ueda et al. is subjected to carburizing treatment or carbonitriding treatment and thereafter heated under vacuum, unlike the steel in the present invention, to reduce the hydrogen content. Thus, the steel of Ueda et al. is very different from the steel in the claimed full-type rolling bearing and roller cam follower. The steel used in the present invention has a non-diffusible hydrogen content of at most 0.5 ppm by the claimed heat treatment, without heating it under vacuum, as in Ueda et al.

In addition, there is no motivation to substitute the steel of Takemura et al. `109 with its costly high chromium content for the steel of Hirakawa et al. The steel types taught by Hirakawa et al. are different from those disclosed by Takemura et al. `109. For example, Takemura et al. `109 disclose a steel requiring 2.0 to 9.0 wt % Cr. Thus, there is no suggestion that the steel types taught by Hirakawa et al. would have the claimed hydrogen content.

The claimed full-type rolling bearings and roller cam followers are further unobvious because SUJ2 steel has a high carbon concentration (0.95% -1.10%). Therefore, it had been difficult to carbonitride SUJ2 steel in the manner disclosed, for example, in Takemura et al. `232 for the following reasons:

i) In order to carbonitride SUJ2 steel, it is necessary to increase the carbon concentration in the carbonitriding atmosphere to an extremely high concentration (for example, Cp = approximately 1.2-1.4), which results in damage to the carbonitriding furnace or causes a phenomenon of deteriorating the productivity of the steel (such as sooting).

ii) In order to prevent the amount of retained austenite from abnormally increasing and ensure a high hardness of the steel, it is necessary to carbonitride the steel at a temperature of approximately 850°C. At this temperature, however, the diffusion coefficient of carbon is low. Thus, even if SUJ2 is carbonitrided, the carbonitrided layer cannot be formed to a suitable depth in the steel.

iii) If carbonitriding is carried out at a temperature higher than 850°C for the purpose of increasing the carbonitriding speed, quenching cracks are likely to occur during quenching.

In addition, if the conventional carbonitriding process as disclosed, for example in Takemura et al. `232, is performed on SUJ2 steel, the crack strength decreases because the carbonitriding process takes a long time or because the amount of retained austenite in the surface layer is large. Therefore, a steel having the properties of the present invention (e.g. - crystal grain size number larger than 10, hydrogen content at most 0.5 ppm, and fracture strength at least 2650 MPa) cannot be obtained. In the present invention, SUJ2 steel is quenched at a low temperature of

790°C to 815°C so the crystal grains can be made finer and hydrogen entering the steel in the carbonitriding process can be discharged to the outside and the amount of retained austenite can be kept small. As a result, the strength of the steel can be enhanced without shortening the rolling life.

The dependent claims are allowable for at least the same reasons as the independent claims and are further distinguishable over the cited references.

In view of the above amendment and remarks, Applicants submit that this application should be allowed and the case passed to issue. If there are any questions regarding this Amendment or the application in general, a telephone call to the undersigned would be appreciated to expedite the prosecution of the application.

To the extent necessary, a petition for an extension of time under 37 C.F.R. § 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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